A Response to

"Ultraviolet Light: Some Considerations for Vision Stimulation"

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A few facts, sketchily reported, can mislead as readily as subjective information can lead to false assumptions. "Ultraviolet Light: Some Considerations for Vision Stimulation" (Education of the Visually Handicapped, Winter 1986) performs this unfortunate disservice. Its intent, which I commend, is to inform our current use of black light as a vision training tool with research findings drawn from current medical journals. Certainly, caution should be exercised in using black light with visually handicapped students--particularly aphakic and albino students, young students, and those taking photosensitizing drugs. In citing the research, however, the author implies the equivalence of all UV light sources and does not acknowledge key differences in the type, intensity, and duration of UV exposure obtainable from sunlight, black light, and other sources. In some instances, the UV source, subjects used, and other critical variables of studies are not mentioned, leaving the reader to wonder at the relevance of their findings. It is obvious, as well, that the author has read selectively, for the medical community is not of one mind concerning the relationship between UV exposure and the various eye disorders she mentions. As a final note, the article recommends an ineffective filter as a solution to potential hazards of black light.

When the issue involves the safety and education of visually handicapped children, it is critical we take the time to thoughtfully review the facts rather than apply the findings of several studies of limited scope to every instance of UV exposure. I would like to take this opportunity to share additional facts and research findings which are necessary to a well-considered evaluation of black light safety.

All ultraviolet light (UV) is not the same in its effects on human and animal tissue. Ultraviolet light (also called UV radiation) is commonly classified into one of three groups according to its wavelength. Wavelengths are measured in nanometers (nm); therefore, UV light with wavelengths of 10-280 nm is termed "short-wave" or UVC; wavelengths ranging from 280-320 nm are referred to as UVB; and wavelengths of 320-400 nm are commonly called "long-wave", or UVA. Both UVC and UVB light are known to cause burns of the skin and eyes when exposure time and intensity are sufficiently high. It is much less certain what effects UVA light has on skin and eyes, though it is apparent that much higher doses of UVA are required to cause observable injury (Sliney, 1983).

Sunlight contains both UVB and UVA radiation, and its total UV output is many times more intense than the output of a 15, 30, or 40 watt fluorescent black light lamp, which primarily produces UVA

radiation (99.96%). There are other variables to be considered, however. Black light is frequently used under darkened conditions which cause the pupil of the eye to enlarge, thereby admitting more light into the eye. Although the UV irradiance of a black light lamp may be as little as 5% of the UV irradiance of sunlight, it is quite possible the retina receives comparable amounts of UV irradiance when exposed to bright sunlight and to black light in a darkened room at 50 cm from the lamp (J. Kielkopf, personal communication, August 14, 1987). On the opposing side, it should be remembered that sunlight contains UVB radiation, known to damage tissue, which is not present in the black light lamps used for vision training. Therefore, studies which link exposure to intense sunlight and the development of cataracts, ocular melanoma, and other disorders are of questionable value in determining the safety of black light unless the additional factors mentioned are researched in greater detail.

In addition to the uncertain relevance of these studies, the medical community is not in agreement concerning their findings. Many are large-scale population studies which can only display a correlation between exposure to sunlight and eye disease. Development of cataracts, as an example, is highly correlated to a number of different risk factors (Chylack, 1984). The Tucker, Shields, Hartge, Augsburger, Hoover, and Fraumeni (1985) article

("Sunlight Exposure as a Risk Factor for Intraocular Malignant Melanoma") cited in "Ultraviolet Light: Some Considerations" drew criticism following its publication. Fitzpatrick and Sober (1985) state that its conclusions should be viewed cautiously and remind readers that

". . . previous studies have failed to suggest a relation between sun exposure and ocular melanoma" (p. 818).

We, as consumers, should also be aware that lens manufacturers have an interest in this controversy. Indications of UV dangers could translate to increased sales of UV-protective lenses and sunglasses; information circulated by manufacturers should be thoughtfully examined.

Returning to the issue of black light exposure as opposed to sunlight exposure: two studies performed by Dr. Seymour Zigman of the University of Rochester specifically address the effects of long-term exposure to black light in albino mice and nonalbino squirrels. In the first study, albino mice were subjected to the light of 40 watt black light lamps for 12 hours daily. Lens opacities were observed after 60 weeks of daily, continuous exposure; retinal damage was observed at 70 weeks (Zigman and Vaughn, 1974). However, normally pigmented gray squirrels subjected to identical conditions showed no sign of lens opacification or retinal damage following 2 years of exposure, at which time the experiment was terminated. Aphakic squirrels, however, did sustain

retinal damage after only a few weeks. While the proteins in the human lens are more similar to those found in the squirrel lens than those of the mouse lens, it is still not possible to predict the effects of chronic exposure to moderate intensities of black light on the <u>human</u> lens and retina based upon these studies (S. Zigman, personal communication, December 9, 1986).

These studies would seem, however, to reinforce other studies which indicate that moderate doses of UVA light present in sunlight may pose a hazard for aphakic and albino individuals (Ham, Ruffolo, Mueller and Guerry, 1980; Kraff, Sanders, Jampol, and Lieberman, 1985; Rapp and Williams, 1980). In the normal human adult eye, 80% of incoming UVA light is absorbed by the crystalline lens (Lerman, 1980). Aphakics, unless fitted with UV-blocking intraocular lenses, lack this natural protection. Abnormally low pigmentation in the albino eye is most likely responsible for greater-than-normal light levels reaching the retina. Individuals receiving photosensitizing drugs may also be more likely to experience adverse effects resulting from exposure to moderate levels of UVA light (Lerman, Megaw, and Gardner, 1982). Although I have read nothing in the literature, it is conceivable that other eye conditions, such as aniridia, coloboma, or a dislocated lens, might also admit more UV light into the eye, thus increasing an individual's risk. As a final important note, it should be known that the crystalline lens in children does not block UVA light

as thoroughly as the mature adult lens. Some measurements have shown as little as 25% of incoming UVA light is blocked by the immature lens; by 25 years of age blockage of UVA has risen to 80% (Lerman, 1980).

To summarize the facts thus far, while moderate doses of black light do not appear to endanger the normal adult eye, aphakic and albino individuals, those with other select eye conditions, and children are at greater risk to experience negative effects associated with black light exposure. Exposure obtained during vision training activities is very low: students look at fluorescent objects which only reflect UVA light and are not direct sources; activities are performed daily for 15-30 minutes. However, it is still not possible to assure the safety of this dosage on the basis of the research which has been done. Similarly, it is not possible to say that dosages received during vision training will cause damage. Two researchers contacted by telephone expressed doubt that the exposure I described would endanger nonalbino, phakic students, but they would not commit to a statement of black light safety, particularly when used with individuals who have ocular abnormalities (R. Krause, personal communication, November 19, 1986; S. Zigman, personal communication, December 9, 1986).

Given the uncertainty surrounding black light safety, the most responsible course of action seems to be use of UV-blocking filters

or lenses during black light activities. The EVH article suggests ordinary window glass be placed as a filter between the child and the fluorescing objects. Glass blocks primarily UVC and UVB light; less than 1/2% of the light produced by the black light lamp would be blocked, thus it is <u>not</u> an effective filter for our purposes. Polycarbonate plastic performs much better, blocking all UV light up to 390 nm and allowing only 5% of the remaining UV light to pass through. (The plastic must be at least 1/8 inch in thickness. It can be purchased under the trade names Lexan and Tuffak from local plastics supply companies.) To be effective, the polycarbonate sheet must be placed between the child's eyes and the fluorescing materials. Since this prevents the child from touching the materials, an alternative is to equip the student with UV-blocking eyewear. Most lab safety and optical supply companies offer untinted, 100% UV-blocking goggles and glasses for under $10.

The author of "Ultraviolet Light: Some Considerations" is right in urging us to evaluate black light safety. Her attempt to do so has misled readers by citing studies of intense UV exposure (unlike the conditions of vision training under black light), by providing inadequate information concerning the differences in UV light and individuals' sensitivity to this special form of light, and by recommending a useless filter as a solution to potential hazards. I hope the additional discussion provided will enable readers to make an informed decision concerning their use of black light.

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Ultraviolet Light: Some Considerations for Vision Stimulation

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ABSTRACT: Exposure to ultraviolet (UV) wave lengths of light has been implicated in many different forms of visual impairment. These include, but may not be limited to, photoretinal burning, cataract formation, malignant melanomas, photokeratitis, and photoallergic drug reactions. Ultraviolet illumination is also used to illuminate visual displays to provide visual stimulation to exceptional children who are visually impaired, mentally retarded, or physically handicapped. Visual stimulation increases the child's awareness of visual information and aids in teaching basic concepts. Precautions are suggested for using UV illumination in light of the various visual abnormalities associated with such exposure.

Although ultraviolet (UV) light is beneficial to humans in limited amounts, exposure can be harmful in excessive amounts. The purpose of this paper is to examine evidence of visual impairment caused by excessive amounts of UV light, and to consider current practices in vision stimulation with regard to these findings.

The human eye is sensitive to only a very small portion of the electromagnetic spectrum. We recognize different wave lengths within the range of 380 to 750 nanometers (nm) as the colors of the spectrum from violet to red. A nanometer is

one billionth of a meter. Beyond the limits of the visible spectrum the eye cannot directly perceive light nor can it perceive objects which reflect energy waves of these frequencies. UV light is composed of comparatively short wave lengths of light (100 nm to 380 nm). As such, UV light is beyond the visible spectrum and not directly perceivable by the human eye. It is, however, important to the health and well-being of humans. Generally, people are aware of the effects UV wave lengths have in causing chemical changes within the body resulting in the production of vitamin D. Vitamin D, in turn, influences the metabolism of calcium and phosphorous, contributing to bone development and the synthesis of melanin in the skin, causing tanning.

An individual is exposed to varying amounts of UV in normal sunlight, depending on the season, the specific environment, and the individual's lifestyle. In temperate and arctic regions the environment receives less direct sunlight and, therefore, less UV light per unit/area. Dense clouds also limit the amount of UV reaching the earth's surface. In colder climates individuals spend large portions of the year in artificial environments where ordinary window glass filters out most UV wave lengths. Indeed, the low exposure to UV by residents of temperate regions can cause subsequent deficiencies of vitamin D.

Ultraviolet Light and Visual Impairment

Temporary discomfort from excessive amounts of UV is almost a universal experience, most often in the painful condition of sunburn, causing soreness and blistering of the skin. Far more serious, however, is the number of visual disorders which implicate UV light as a causal factor. For example, directly fixating and focusing on the sun can cause solar retinitis and thermal burning of the macula (Vaughn & Asbury, 1983). The macula is the area of the retina with greatest acuity. In reading, the individual focuses the incoming light rays on the macula. For decades, ophthalmologists have cautioned against any type of direct observation of the sun without proper filters. Even under cloudy or hazy conditions, sufficient UV light can penetrate the earth's atmosphere to cause severe burns to the person who has not taken proper precautions. Furthermore, the sun does not have to be directly fixated for damage to occur. Leavitt (1983), an opthalmologist, described the case of a patient who had permanently damaged the macula in both eyes by reading on the beach. This patient had been reading a book with glossy pages under intense sunlight. The page reflected the light, including UV rays, into her eyes. As she read, she focused the rays on the macula, causing permanent damage. Zigman's (1983) extensive review of research concludes that UV radiation stimulates cataract formation. It appears that UV light alters the biochemistry of the lens proteins and damage to the eye is cumulative. Although sunlight is the main source of UV radiation, artificial sources including fluorescent lights, the light from certain equipment in the workplace (e.g., arc

welders and videodisplay terminals), and the ultraviolet lamps used in tanning parlors are also of concern.

Tucker, Shields, Hartge, Augsburger, Hoover, and Fraumeni (1985) maintain that exposure to intense sunlight, especially during early childhood, may contribute to intraocular malignant melanoma, or malignant cancer within the eye. This type of cancer is related to malignant melanoma of the skin which has long been associated with exposure to sunlight and UV light. Two thousand people in the United States acquire intraocular malignant melanoma annually.

Millodot and Earlam (1984) reported that UV radiation produces photokeratitis or photophthalmia. The clinical signs usually occur after a latent period of 4–5 hours, varying with the intensity of exposure. Subtle metabolic changes in the cornea can occur with UV exposure below that necessary to induce photophthalmia. Finally, studies with various drugs (Hull, Csukas, & Gree, 1982) present evidence that certain drugs induce phototoxicity and photoallergic reactions in the cornea.

Vision Stimulation

Vision stimulation is recognized as important, if not imperative, to the development of visual behavior (Hubel & Weisel, 1963). Barraga (1964) was able to demonstrate increased visual behavior in children with low vision who received systematic visual stimulation. Under normal circumstances an infant develops sophisticated visual behavior without any special intervention. Extensive reviews of the literature on developing efficiency in visual functioning (Barraga, Collins, & Hollis, 1977) summarize the progressive development of visual functioning in visually impaired children and suggest that the principles that apply to normal visual development are also valid for individuals where the processes may be delayed or underdeveloped. A current practice is to provide visual stimulation to visually impaired children using ultraviolet light. Studies on the use of UV light with exceptional children attest to the effectiveness of visual stimulation when using UV light (Hartman & Richards, 1969; Poland & Doebler, 1980; Potenski, 1983). Some teachers working with visually handicapped infants or severely handicapped children have noted that they can elicit visual responses from the children under UV conditions when all other attempts under non-UV lighting have failed.

The reasons for the effectiveness of UV illumination may be the result of decreasing the visual background in the environment, or eliminating "visual noise." By enhancing the figure/ground contrast, the child can more easily focus attention on only selective areas of the total environment. An alternative explanation may be that the fluorescence of the object provides some type of intensified stimulation to the retina or cerebral cortex, thus enabling the child to process environmental information in a more meaningful way.

In vision stimulation training, a teacher may use UV light first to elicit visual behavior. The child is made aware of visual sensations and encouraged to respond visually to objects in the environment. At a more advanced level the child is encouraged to fixate and pursue objects that are presented under UV illumination. At the more advanced levels of vision stimulation, UV illumination of objects aids in concept formation. Many objects, often those of synthetic fabric or certain plastics, will fluoresce when illuminated with UV light. When such objects are illuminated by UV light in a dimly lit environment they emit light and glow. The enhanced figure/ground contrasts present the child with optimal conditions for learning such basic concepts as size, seriation, and categorization. As the child develops the ability to use visual information, the UV light is gradually withdrawn and the child should learn to respond under more natural environmental illumination.

Considerations When Using UV Light

The intent of this paper is neither to recommend nor discourage the use of UV light. Rather, it proposes to increase awareness of the potential short-term and long-term hazards inherent in the use of UV light and suggests safer procedures for those who elect to use it. When UV light is incorporated into a vision stimulation program, both the child and teacher are exposed to potentially harmful wave lengths. It is possible that the teacher may have even greater exposure than the child since he or she often works with several children during the course of the day. Also, the teacher may be in a position to receive more direct UV light; for example, he or she may face the light source while working with the child.

Vision stimulation is frequently used by children who are visually impaired, mentally retarded, or physically handicapped. Light-gazing is often exhibited by children with these disabilities. If a child is positioned so that he or she can directly perceive the UV light source, the child may receive excessive UV exposure. It is particularly important to note that under low illumination the pupil of the eye is dilated, thus allowing a greater area for the penetration of potentially harmful rays.

Normal sunlight has relatively low concentrations of UV light. When UV light is used in vision stimulation, however, an individual is exposed to much greater concentrations of the shorter wave lengths of light than under normal conditions. Furthermore, UV light can have cumulative effects (Tucker et al., 1985; Zigman, 1983). Individuals exposed to UV light are subject to ocular damage depending on both the intensity of the light source and duration of the exposure. The risk exists even when the light may seem less intense, because UV light does not create visible illumination. The harmful wave lengths are not within the visible spectrum and, therefore, cannot be directly perceived.

The lens of the normal eye acts as a natural filter for UV wave lengths. However, the previously cited findings of ocular disease indicate that the lens is

not a totally effective filter. Furthermore, in children with certain types of visual impairment, the lens may have been surgically removed (aphakia). When either the teacher or the child is aphakic, extreme caution is necessary when using UV light because the natural filter is no longer present. Fortunately, most individuals who have had cataracts removed and are aphakic wear some form of artificial lenses. Artificial lenses can filter UV wave lengths, but not all materials used in manufacturing these lenses are equally effective (Anderson & Gebel, 1977).

The evidence implicating UV wave lengths as causal agents in eye disorders is incomplete at this time. However, practitioners should be aware of potential hazards and need to monitor the use of UV light in vision stimulation very carefully. Safe use of UV light requires great caution. When using a source of UV light specifically designed for vision stimulation, particular attention should be paid to the following important factors:

1. *The position of the child in relationship to the UV light source.* The child should not be positioned to observe the light source directly. See Figure 1. This is particularly important in working with children who are known to be "light-gazers."

2. *The position of the teacher in relationship to the UV light source.* Precautions should be taken so that the teacher will not be inadvertently looking into the light when conducting vision stimulation activities.

3. *Possible use of window glass filters during training.* If the UV light source is shielded by ordinary glass between the UV source and the objects, little UV light will reach the objects and they will not fluoresce. A shield of ordinary window glass could be placed between the child and the UV apparatus as shown in Figure 2. Thus, both the light and the fluorescing object would be behind the shield.

4. *Possible use of protective glasses by the teacher and student, to shield their eyes.*

Figure 1. Child is seated wearing glasses. UV light is behind child and above right shoulder.

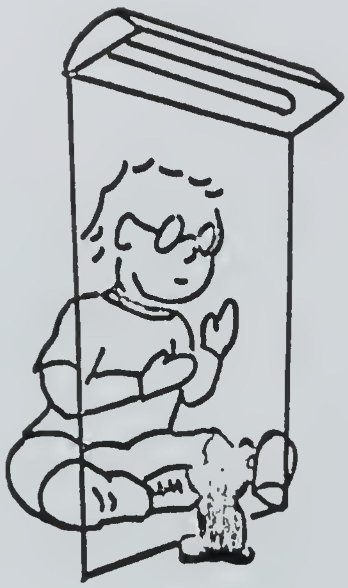

Figure 2. Glass screen is positioned between child and UV light source.

5. *Time limits for length of exposure.* These need to be carefully monitored. No "safe" standards of exposure have been developed for educational uses. Evidence indicates that the effects of UV exposure are cumulative.

6. *Careful monitoring and record keeping of all UV stimulation and intervention.* This should be done for future reference. Vision stimulation has been shown to be beneficial. However, with the recent findings correlating UV light with eye disorders, careful documentation of specific treatment will be extremely important in developing precise criteria for safe practice.

Summary

Evidence from many sources indicates that a variety of visual defects are correlated with exposure to UV light. Indeed almost all structures of the eye can be affected in some manner. Caution must be exercised when ultraviolet light is used to stimulate vision. Careless use and monitoring of UV light may result in damage to the perceptual system that is in the process of developing, or it may result in reduced visual ability at a much later time due to induced cataracts or ocular melanomas.

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